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Gut content analysis of the Collembolan *Bourletiella hortensis* (Fitch) from a forest nursery

BY

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INTRODUCTION

Bourletiella hortensis (Fitch) feeds on a host of plant species (MACNAMARA, 1924; MAYNARD, 1951). Evidence that this insect might cause damage in forest nurseries (MARSHALL and ILNYTZKY, 1976) prompted a study on its feeding habits, by gut content analysis, as a supplementary method of assessing its damage potential to germinating conifer seedlings. Gut content analysis has certain limitations, because it emphasizes the relative importance of durable, non-digestible materials while underestimating the quickly digestible and transparent matter, and ignores liquids (MACMILLAN and HEALEY, 1971). Nevertheless, it is the technique most easily implemented for studying the natural feeding habits of collembola under field conditions.

MATERIALS AND METHODS

Specimens of *B. hortensis* were randomly collected from the soil surface in the same area (1.6 × 100 m) of the Koksilah Nursery at Duncan, British Columbia. The soil, a silt loam with a pH of 5.6, was cultivated in mid-April and tractor-sown to Sitka spruce [*Picea sitchensis* (Bong.) Carr.] on May 1. Sampling was carried out once in April, four times in June and once in July, 1973. Individuals were swept upon large index cards and transferred to vials containing 70 % ethyl alcohol.

The method for gut content analysis was essentially that of POOLE (1959). Specimens were placed in cold lactophenol for about 1 week or until they were partially cleared, but with the cuticle still intact. From specimens with visible gut content, 12 individuals (four each of young, pre-adults and adults) were randomly selected from each sampling date for gut content analysis. Gut contents of adults and pre-adults were dissected in a small drop of polyvinyl alcohol (SALMON, 1954) on a microscope slide and squashed beneath a round 13-mm diameter cover slip. Young specimens were squashed without being dissected. The drop of mountant used was about the same size for each specimen and

just sufficient to disperse the gut content beneath the cover slip. This ensures good dispersion of the gut material in about the same depth of liquid. The slides were examined microscopically under phase contrast and polarized light at magnifications up to 1000X.

Nine categories of materials were classified and counted: mineral particles, amorphous mass (unidentifiable particulate organic matter), pollen grains, fungal hyphae, fungal spores, higher plant tissue, algae, diatoms and yeasts. The food in each category of the entire intestinal smear was examined at 400X. The proportion of each food category was estimated on a scale of 1-10 for each field of view, using a hairline graticule. The values were averaged and were expressed as a percentage of the entire gut smear.

The data were transformed by square roots, to compensate for zero counts, and statistically analysed as a completely random design. Significance ($P \leq 0.01$) of each mean difference was determined by the Student-Newman-Keul's test (STEEL and TORRIE, 1960).

RESULTS AND DISCUSSION

Of the 240 specimens of *B. hortensis* carefully examined, 18 % of young, 32 % of pre-adults and 32 % of adults had no visible gut content. ANDERSON and HEALEY (1972), CHRISTEN (1975), KNIGHT and ANGEL (1967), and POOLE (1959) found that about 21 to 66 % of individuals of different collembolan species examined had « empty » guts. ADDISON (1975) observed a high proportion of « empty » guts in a field population of two species (91 % in *Folsomia regularis* Hammer and 87 % in *Hypogastrura tullbergi* Schäffer) and suggested that Collembola voided their guts during funnel extraction. The latter idea is not supported by my study with *B. hortensis*, because specimens were collected directly from the field and placed in alcohol.

Significant ($P \leq 0.01$) differences in the major gut components occurred in young *B. hortensis* among different sampling dates (Tab. I). Pre-adults and adults had similar quantities of material in their gut throughout the study period. On two occasions (April 3 and June 19), pre-adults contained substantial quantities of pollen grains, but this was not statistically significant from other sampling dates. Significantly different amounts of fungal spores occurred among young *B. hortensis* only on the April 3 sampling. In all three stages, algae comprised the smallest component of the food. Fungal hyphae and spores, higher plant tissue, yeasts and diatoms varied in ranking throughout the sampling period. A few individuals contained a high proportion of a single food, such as fungal spores or pollen grains.

The three collembolan stages showed significant differences in the amounts of major food components. The young contained more pollen grains than pre-adults and adults, which had more mineral particles and amorphous mass (Tab. II). The mean percentage distribution for the nine categories of food (Fig. 1-14) is also shown in Table II.

The high percentage of amorphous mass agrees with BÖDVARSSON's (1970) observations for some common soil inhabiting Collembola in southern Sweden. Unfortunately, amorphous mass does not indicate the origin of the food, as digested pollen grains or other easily digested materials would fall into this category.

Mineral particles composed a relatively high proportion of the gut content of *Onychiurus armatus* Tullberg, *O. furcifer* Börner and *Tullbergia callipygos*

TABLE I

Composition of the gut content of three arbitrary stages of *Bourletiella hortensis*. Values are percentages of the total identified material from each sampling date

	3.IV.73	6.VI.73	12.VI.73	19.VI.73	26.VI.73	5.VII.73
YOUNG						
Mineral particles	14 a*	38 b	45 b	18 a	34 b	52 b
Amorphous mass	10 a	47 b	41 b	24 a	53 b	43 b
Pollen grains	61 a	7 b	13 b	57 a	4 b	5 b
Fungal hyphae	0	3	1	0	5	0
Fungal spores	15 a	1 b	0 b	0 b	0 b	0 b
Higher plant tissue	0	3	0	0	3	0
Algae	0	0	0	0	0	0
Diatoms	0	1	0	0	1	0
Yeasts	0	0	0	1	0	0
PRE-ADULT						
Mineral particles	40	41	45	33	42	46
Amorphous mass	40	41	40	38	54	41
Pollen grains	19	9	6	24	3	12
Fungal hyphae	0	1	0	3	0	1
Fungal spores	0	1	0	1	0	0
Higher plant tissue	0	3	6	0	0	0
Algae	0	1	0	0	0	0
Diatoms	0	3	0	1	1	0
Yeasts	1	0	3	0	0	0
ADULTS						
Mineral particles	40	46	53	45	45	41
Amorphous mass	48	40	35	46	45	47
Pollen grains	8	5	3	8	5	4
Fungal hyphae	1	3	3	0	1	1
Fungal spores	0	1	0	1	1	0
Higher plant tissue	0	3	5	0	2	2
Algae	0	1	1	0	0	0
Diatoms	0	1	0	0	1	0
Yeasts	1	0	0	0	0	5

* Values read horizontally without letters or those followed by the same letter are not significantly different ($P \leqslant 0.01$).

Börner (McMillan, 1975) and were frequently encountered in the Symphypleona, *Megalothorax minimus* Willem (BÖDVARSSON, 1970). However, the very high percentage of mineral particles in *B. hortensis* was surprising and may be attributed to the use of sand to cover seeds after sowing; therefore it could be easily ingested by this surface-dwelling species.

Although some collembolans feed mainly on fungi (MILLS and SINHA, 1971; STAINER and KEVAN, 1973), the importance of fungal material in collembolan diet is controversial. The low quantity of fungal material found in the gut of *B. hortensis* supports BÖDVARSSON's (1970) observations that fungal

TABLE II

Mean percentage of major gut components in *Bourletiella hortensis* captured from April to July, 1973

	Young	Pre-adult	Adult	Mean
Mineral particles	33.5 a*	41.2 b	44.8 b	39.8
Amorphous mass	36.5 a	42.4 b	43.3 b	40.7
Pollen grains	24.6 a	12.1 b	6.2 b	14.3
Fungal hyphae	1.5	0.8	1.4	1.2
Fungal spores	2.6	0.4	0.6	1.2
Higher plant tissue	0.8	1.5	2.0	1.4
Algae	0.0	0.2	0.4	0.2
Diatoms	0.3	0.8	0.3	0.5
Yeasts	0.2	0.6	1.0	0.6

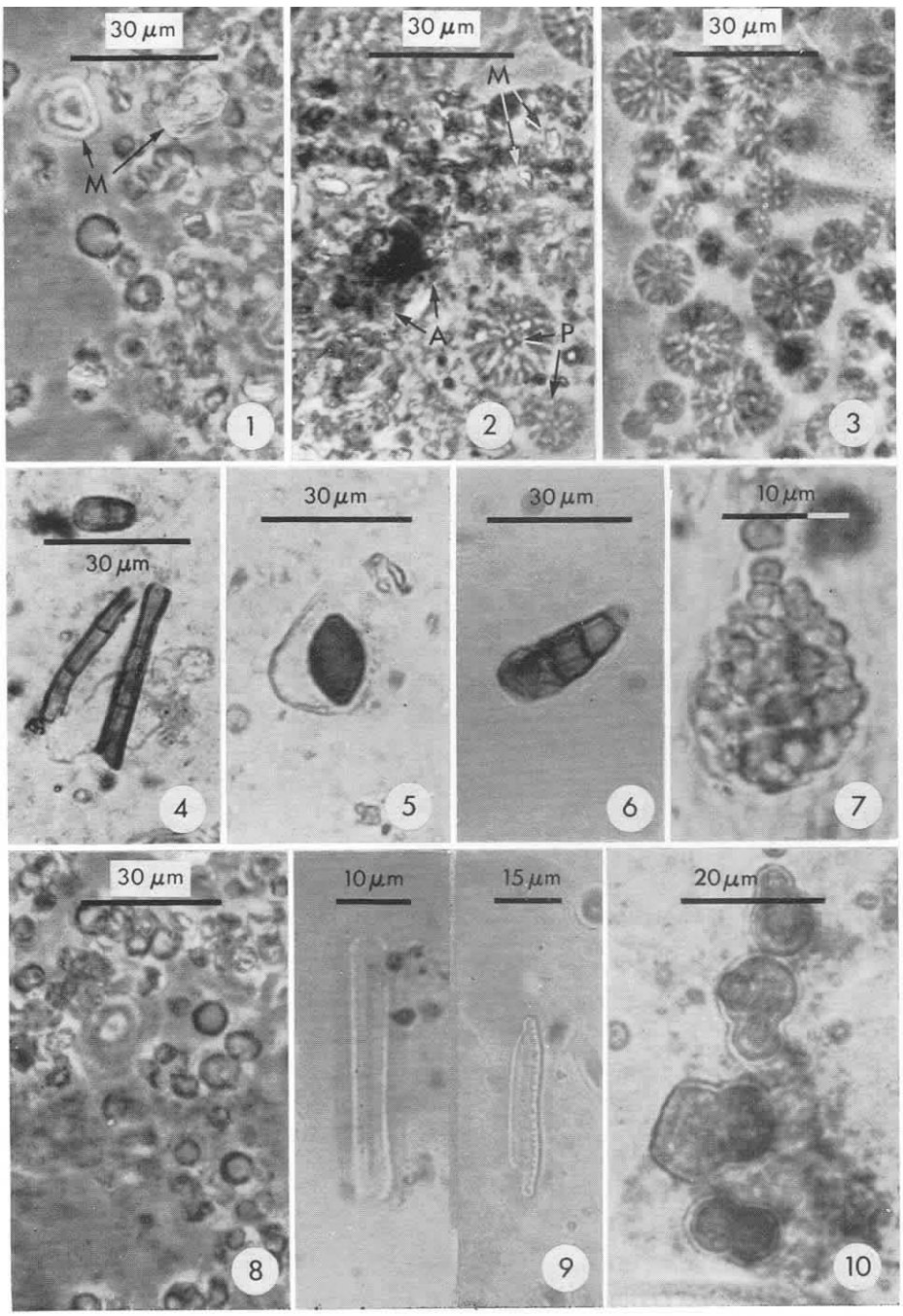
* Values read horizontally without letters or those followed by the same letter are not significantly different ($P \leqslant 0.01$).

hyphae do not seem to be as common an ingredient of collembolan food as statements in the literature would indicate.

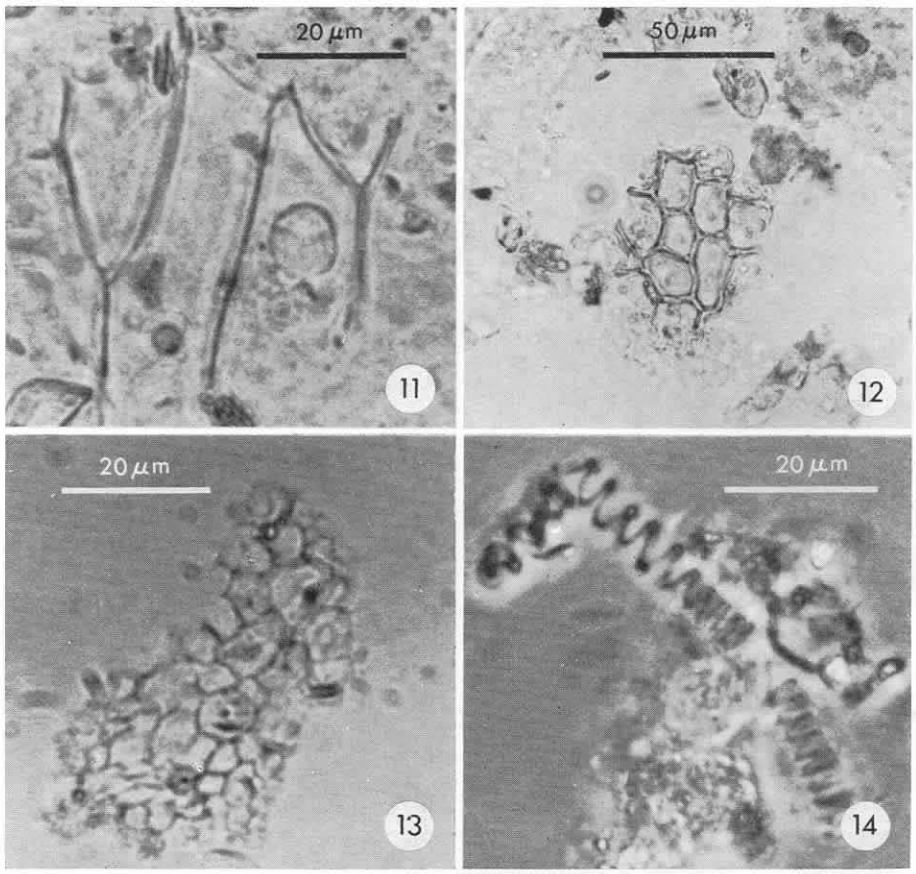
Pollen grains are a highly valuable food with all the basic nutrition for animals able to use it (KEVAN and KEVAN, 1970). *B. hortensis*, or forms considered to be the same species by Maynard (1951) — e.g. *B. pruinosa* (Tullberg) and *B. signata* (Nicolet) — is known as a pollen feeder (HANDSCHIN, 1924; MACNAMARA, 1924; FOLSOM, 1934; BÖDVARSSON, 1957). In *B. hortensis* from the Koksilah Nursery, various types of pollen grains were observed in different stages of comminution, confirming SCOTT and STOJANOVICH's (1963) observation that collembola ingest as well as digest pollen grains.

Figures 11-14 show four main types of materials, apart from pollen grains, considered to be from higher plants. Since wood chips were used to minimize frost heaving in crops previously grown in the sampling area, it is difficult to determine the origin of this material. Some of these materials appear to be from tracheids (Fig. 11), primary tissue of pith (Fig. 12), leaf tissue (Fig. 13) and spiral thickenings of young tracheids (Fig. 14). Therefore, they likely originated from conifer seedlings or weeds, as the nursery was seeded on May 1 and higher plant tissue did not occur in the gut contents of young, pre-adult or adult before this date (Tab. I).

The composition of the gut content of *B. hortensis* suggests that, beyond a preference for pollen grains in the young, this species is an unspecialized indiscriminate feeder and, in the nursery, does not show a preference for higher plant material. Because of the large proportion of materials other than plant tissue consumed, and the inability of the method used to measure the feeding on plant juices by this insect, gut content analysis was of limited value in studying damage potential in germinating conifer seedlings. Since Collembola will feed on almost any food provided (CHRISTIANSEN, 1964), other types of experiments, including the study of gut content under different cropping conditions, are required to obtain a fuller understanding of feeding habits and damage potential of this species.



FIGS. 1-10. — Representatives of major categories of food from the gut of *B. hortensis*. 1, Large mineral particles (M) showing sharp jagged adges. 2, Amorphous material (A) mixed with fine mineral particles (M) and pollen grains (P). 3, Mass of pollen grains. 4, Fungal hyphae or conidiophores with *Bispora* conidium. 5, Ascospore of Melanosporaceae. 6, Conidium resembling that of *Alternaria*. 7, Cluster of spores. 8, Algal cells. 9, Two examples of pinnate diatoms. 10, Budding yeast cells.



FIGS. 11-14. — Tissue of higher plants that appear to be tracheids (Fig. 11), from pre-adult (12.VI.73) ; primary tissue of pith (Fig. 12) from pre-adult (12.VI.73) ; leaf tissue (Fig. 13), from young (6.VI.73) ; and spiral thickening of young tracheids (Fig. 14) from adult (12.VI.73).

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SUMMARY

The percentage distribution of the main categories of food from the gut content of *Bourletiella hortensis*, from a forest nursery on Vancouver Island, British Columbia, during April to July 1973, was: amorphous mass (40.7), mineral particles (39.8), pollen grains (14.3), higher plant tissue (1.4), fungal hyphae (1.2), fungal spores (1.2), yeasts (0.6), diatoms (0.5) and algae (0.2).

Significant ($P \leq 0.01$) differences for sampling dates were obtained only in young specimens, in which pollen grains increased inversely to amorphous mass and mineral particles. Also, young *B. hortensis* consumed more pollen grains than pre-adults and adults, which ate more mineral particles and amorphous mass. Because only a small quantity of plant tissue was detected in the gut material, further studies under different cropping conditions are required to obtain a better understanding of the feeding habits of this insect in relation to plant damage.

Résumé

Le pourcentage des principales catégories de nourriture provenant de l'intestin de *Bourletiella hortensis* dans une pépinière forestière de l'île de Vancouver, Colombie-britannique durant la période d'avril à juillet 1973, était distribué comme suit : masse amorphe (40.7), particules minérales (39.8), grains de pollen (14.3), tissu de plantes développées (1.4), hyphes fongiques (1.2), spores fongiques (1.2), levures (0.6), diatomées (0.5), et algues (0.2).

Des différences significatives ($P \leq 0.01$) quant aux dates d'échantillonnage étaient observées chez les jeunes spécimens seulement dans lesquels les grains de pollen augmentaient inversement à la masse amorphe et aux particules minérales. De plus, les jeunes *B. hortensis* consumaient plus de grains de pollen que les pré-adultes et adultes, qui ingurgitaient plus de particules minérales et de masse amorphe. Du fait que seulement une faible quantité de tissu végétal était décelée dans l'intestin de l'insecte, il faudra procéder à de nouvelles études sous diverses conditions de récolte pour obtenir une meilleure connaissance des habitudes alimentaires de cet insecte en rapport avec les dégâts qu'il cause aux plantes.

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